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The percentage deviations obtained for the several series by the process just described have a wide range of distribution for some series and a narrow range for others. For instance, during the period 1903-16 New York bank clearings ranged from -49 per cent to +64 per cent; outside bank clearings, from -23 per cent to +33 per cent; and the rate of interest on ten railway bonds, from -4 per cent to +11 per cent. This difference in range means that a deviation of +10 per cent in one series indicates quite a different thing from what is indicated by a similar percentage deviation in another series. That is, in *judging* the meaning of fluctuations of different series, percentages are not proper units to use. The problem, therefore, is to express the deviations of different series in comparable terms. What is a "normal" fluctuation for each series? To answer this question a unit must be constructed for each series, which unit must depend upon the dispersion of percentage deviations in such series, so that the greater the dispersion the greater the unit. The range of the items is not a good measure of dispersion because it does not depend upon the distribution of the items between the maximum and the minimum. We need a measure of dispersion that, like an average, depends upon all the items of the series. Of various measures which have been used by statisticians, the *standard deviation* is, without question, the most important and satisfactory. "The standard deviation is the square root of the arithmetic mean of the squares of all deviations, deviations being measured from the arithmetic mean of the observations."¹ In the present instance the "observations" are percentage deviations from the corrected secular trend. Since the arithmetic average of the positive and negative percentage deviations is approximately zero,² the standard deviation is the square root of the arithmetic mean of the squares of the items we are using. In comparing the significance of fluctuations of different series we shall express the percentage deviations in terms of the respective standard deviations as units. The standard deviations, 1903-16, are given in Table F.

Graphs of the percentage deviations, 1903-18, in terms of the standard deviations, 1903-16, as units, are given in Charts 101 to 114. These charts picture the fluctuation corrected for (a) secular trend and (b) seasonal variation, and expressed (c) in units appropriate for the comparison of different series.

The first part of our task, the development of a method of analyzing each series by itself, has been com-

¹ For a discussion of this subject see Yule's *Theory of Statistics*, chap. 8. If x represents deviations from the arithmetic mean, n represents the number of items, and σ the standard deviation we have

$$\sigma^2 = \frac{1}{n} \sum (x^2).$$

If ξ represents the deviations from an arbitrary quantity, and d represents the difference between the arithmetic mean and the arbitrary quantity, we have

$$\sigma^2 = \frac{1}{n} \sum (\xi^2) + d^2.$$

² For instance in the case of imports of merchandise the algebraic sum of the percentage deviations was + 24 and the absolute sum was 1510. The standard deviation of 11.91, computed on the assumption that the algebraic sum is zero, is not altered by correcting for the slight discrepancy.

TABLE F—STANDARD DEVIATIONS OF THE RELATIVE DEVIATIONS OF THE ORIGINAL SERIES FROM THE LINE OF SECULAR TREND CORRECTED FOR SEASONAL VARIATION *

Name of Series	Standard Deviation
1. New York Clearings	20.3
2. Production of Pig Iron	19.15
3. Outside Clearings	8.62
4. Bradstreet's Prices	3.68
5. Imports	11.91
6. Building Permits	20.4
7. Railroad Gross Earnings	6.07
8. Shares Traded	49.6
9. Unfilled Orders U. S. S. C.	†
10. Tonnage Entered	†
11. Business Failures (Bradstreet)	13.55
12. Rate on 10 Railroad Bonds	2.82
13. Rate on 4-6 Months Paper	16.46
14. Rate on 60-90 Day Paper	19.66
15. Rate on Call Loans	†

* These are the units used in Charts 101-115 to secure comparable graphs. † Not computed.

pleted. A summary of the method, the sources and the nature of the data used, conclusions resulting from the application of the method to selected series, tables giving all essential figures, and charts presenting the results graphically—these form the subject matter of Part II.

5. REMAINING PROBLEMS OF METHOD AND INTERPRETATION

Having developed a method of correcting each series for the elements not significant of business conditions, and having applied that method to individual series, certain important and difficult problems remain to be considered. Indeed, the separate analysis and correction of each series by itself is but one step in a series of three which must be made before statistical data may properly be used as indices of business conditions. The corrected series having been interpreted individually, the second step is to construct a method for studying them in relation to each other and to the economic history of the period covered. Such a comparative study will enable one to make generalizations, based on a number of series, concerning the business conditions of a *past* period. As has been said in the preceding discussion, however, the value of generalizations based on past data depends upon the applicability of such generalizations to the present. The aim of the entire analysis is to evolve a method whereby current statistics may be used as a guide to current business conditions. Having established a means of correcting individual series, therefore, and having, further, developed a method for comparative study of fluctuations in different series, there will remain a third requirement. If the data of the past are to be used as a clue to the present, we must show that economic organization and business usage have not so altered as to change the significance of the data.

The present number of the REVIEW, then, is devoted to a treatment of the first of the three problems which,

when solved, will provide a method of constructing indices of business conditions. In later numbers the second and third problems will be considered. Looking to the past, the specific questions to be answered are:

What series constituted good indices of business conditions and what ones did not?

In answering the question just stated, how may we set up a standard for judgment?

Have fluctuations in certain series systematically anticipated the fluctuations in others, or did they all occur simultaneously?

If the fluctuations of certain series anticipated, or lagged behind, those of other series, what was the degree of anticipation, or of lag?

Looking to the present and future, the specific questions encountered are:

Do the series which served satisfactorily for a past period serve as well today?

How have the various series been affected by the transition from peace to war?

What change will probably take place in the transition from war to peace?

If old series have lost their significance as indices of business conditions, may other series be substituted for them? Is it possible to apply the lessons of the past to new data?

These questions, which involve the further development of statistical method, application of method, critical analysis of data, and interpretation of results, are reserved for consideration in the next number of the REVIEW OF ECONOMIC STATISTICS.

II. APPLICATION OF THE METHOD TO INDIVIDUAL SERIES

I. OUTLINE OF THE METHOD

(a) The data necessary for the application of the method are homogeneous monthly series of statistics covering a period of, say, fifteen years or more.

(b) The linear secular trend is found by fitting a straight line to annual items by the method of least squares. The compound interest curve, parabola, or other curves are used in case a straight line does not give satisfactory results.

(c) Indices of seasonal variation are found by taking the medians of month-to-month percentages for each of the twelve months. The medians, thus found, are progressively multiplied to form a continuous series, the discrepancy due to secular trend is distributed, and the average is made equal to 100.

(d) The original items are corrected for secular trend and seasonal variation, as follows: each monthly ordinate of secular trend is multiplied by the index of seasonal variation for that month; the resulting product is subtracted from the corresponding original item, and then expressed as a percentage of the ordinate of secular trend.

(e) The percentage deviations of the various series are expressed in terms of their respective standard

deviations, in order to secure comparable cyclical fluctuations.

2. ACCURACY IN DATA AND COMPUTATION

The items of the statistical series studied have been taken to three or four significant figures only. There are several reasons for doing this. First, the items of the series are probably not reliable beyond the fourth digit; second, even if the items were accurate to more digits a change in such digits would rarely be significant; third, the use of additional digits would enormously increase the labor of handling the data; and fourth, the limited extent of monthly data does not, in general, warrant us in measuring seasonal and other variations more closely than to the nearest per cent.

Since the margin of error of our corrected figures depends upon the accuracy of the measurements of secular trend and seasonal variation as well as upon the accuracy of the original figures, it is clear that the least accurate of these figures sets the limit of desirable refinement in computation. In general, then, the computations were carried to the nearest per cent only. This degree of accuracy was used in computing month-to-month link relatives, except for Bradstreet's prices and for interest rates, for which series the computation was carried to tenths of a per cent. Especial care was taken to keep out cumulative errors, resulting from approximations.

In computing percentages a ten- or twenty-inch slide rule was used. Every computation was checked; the plan followed was to have two computations made by independent computers, the results compared, discrepancies noted, and the items in disagreement re-computed independently and re-compared. The probable error of the final figures depends upon the error of the original figures, the extent of the data, and upon the probable errors of the determination of secular trend and seasonal variation. The errors of the original figures are dependent upon the accuracy of collection of the data and upon the nature and extent of the sample, if the items are samples. The probable error of the determination of the secular trend cannot be stated definitely. The only test we have is the accuracy of the fit of the line to the data covering a period of sufficient length. The probable error of the indices of seasonal variation depends upon the closeness of grouping of the relatives. To illustrate, we may compute "indices of seasonal variation" for the number of shares traded on the New York Stock Exchange. But, even granting seasonal variation, it is not possible to measure the fluctuations closer than to 10 per cent. In the case of outside bank clearings, however, the measurement is probably accurate to 1 per cent. In the case of yield on railroad bonds the seasonal variation must be measured to tenths of a per cent, if measured at all.

The use of the median to measure the seasonal variation reveals clearly the fact that the resulting measurement is an approximation that, in exceptional cases, might be changed several per cent by the inclusion of a